

# On the phase dependence of a reversed quantum transitions

V.A. Kuz'menko<sup>1</sup>

*Troitsk Institute for Innovation and Fusion Research,  
Troitsk, Moscow region, 142190, Russian Federation.*

## Abstract

Physical nature of widely known Ramsey fringes phenomenon is discussed.

PACS number: 78.47.jm, 42.50.-p

Ramsey fringes are an oscillation in population transfer in a two-level quantum system under action of an external driving field, which is split in space or in time [1]. Although, the phenomenon is known for many years, it does not have clear physical explanation. However, such explanation is very simple: this is a result of natural property of a reversed quantum transition its cross-section depends on the phase of driving field.

Let us discuss recent classical pump-probe experimental study of interaction of femtosecond laser pulses with Rb vapor [2]. When very weak collinear fs laser pulse interacts with unexcited atoms before the main pump pulse, the phase modulation is absent. But rather strong phase modulation exists when the probe pulse pass during or after the pump pulse and interacts also with the excited atoms. Such results usually are explained by a quantum interference of "wave-packets", which are formed by two laser pulses [3]. However, this is not a physical explanation. A photon has some energy. This energy can not disappear. When after the second laser pulse population of excited states vanish, it means that efficient stimulated emission takes place and we should say about high cross-section of reversed process. We have sufficient experimental proofs of strong inequality of differential cross-sections of forward and reversed transitions in optics [4].

The phase sensitivity is a property of only reversed transitions. The experiments clearly show that forward transition to any other quantum state does not have the specific dependence from the phase of the second laser pulse [5, 6]. Other beautiful experiment with diamond configuration of used quantum levels in Rb shows that forward and reversed pathway may be not coincide with each other [7]. Only the initial and final states of a quantum system must exactly coincide. This demand can explain why we do not see efficient three photon mixing processes in a gas phase. Each photon has a spin. So, using odd number of photons it is impossible to return a quantum system exactly into the initial state. In a solid state a crystal lattice can eliminate the role of a spin and we can see efficient three photon mixing processes. In a gas phase efficient photon

---

<sup>1</sup>Electronic address: kuzmenko@triniti.ru

mixing processes are possible only with an even number of photons, that we can see, for example, in a high harmonic generation process [8].

Experimental study of reversed transitions is rather simple: in a common case we need in a pump-probe apparatus with a collinear sufficiently weak probe pulse, which does not considerably modify the population distribution of quantum states [9]. Unfortunately, such experimental results are practically absent in literature.

For a long time a scientists try to invent an empirical methods of so-called "coherent control" [10 - 13] instead of to study its physical base: inequality of forward and reversed processes or time noninvariance in quantum physics.

## References

- [1] N.F. Ramsey, Phys. Rev. **78**, 695 (1950).
- [2] J.C. Delagnes and M.A. Bouchene, Phys. Rev. A **76**, 053809 (2007).
- [3] N.F. Scherer, R.J. Carlson, A. Matro, M. Du, A.J. Ruggiero, V. Romero-Rochin, J.A. Cina, G.R. Fleming and S.A. Rice, J. Chem. Phys. **95**, 1487 (1991).
- [4] V.A. Kuz'menko, e-print, arXiv:physics/0506023
- [5] K. Ohmori, H. Katsuki, H. Chiba, M. Honda, Y. Hagihara, K. Fujiwara, Y. Sato and K. Ueda, Phys. Rev. Lett. **96**, 093002 (2006).
- [6] H. Katsuki, K. Hosaka, H. Chiba and K. Ohmori, Phys. Rev. A **76**, 013403 (2007).
- [7] M.C. Stowe, A. Pe'er and J. Ye, Phys. Rev. Lett. **100**, 203001 (2008).
- [8] T. Brabec and F. Krausz, Rev. Mod. Phys. **72**, 545 (2000).
- [9] V.A. Kuz'menko, e-print, arXiv:0706.2488v1
- [10] W.S. Warren, H. Rabitz and D. Mahleh, Science **259**, 1581 (1993).
- [11] M. Shapiro and P. Brumer, *Principles of the quantum control of molecular processes* (Willey, New Jersey, 2003).
- [12] M.C. Stowe, M.J. Thorpe, A. Peer, J. Ye, J.E. Stalnaker, V. Gerginov and S.A. Diddams, Adv. At. Mol. Opt. Phys. **55**, 1 (2008).
- [13] A. Gandman, L. Rybak and Z. Amitay, e-print, arXiv:0910.3581